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6. AUTHOR(S)

Dr. David M. Rust

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

The Johns Hopkins University
Applied Physics Laboratory
Johns Hopkins Road, Laurel MD 10723

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AFOSR/NM
110 Duncan Avenue Suite B115
Bolling AFB DC 20332-8050

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The principal effort was development and flight of the Flare Genesis Experiment (FGE). The FGE is a balloon-borne solar telescope that can provide the sharpest view ever of the evolution of activity on the Sun. The goal of the FGE is to obtain the observations needed for a breakthrough in solar flare research both sooner and at significnatly lower cost than either a satellite or adaptive optics can offer. The FGE flight was an histofic first. This effort has shown that a meter-class solar telescope can take advantage of the modern long-duration ballooning program in Artarctica to achieve science goals that are central to solar activity research.

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Title: SOLAR VECTOR MAGNETIC FIELD RESEARCH - Final Report

Principal Investigator: Dr. David M. Rust

Organization: The Johns Hopkins University
Applied Physics Laboratory
Johns Hopkins Road, Laurel, MD 20723

Agency: Air Force Office of Scientific Research
Bolling AFB, DC
Attention: Dr. Henry Radoski

Summary of Effort:

The principal focus of effort during the grant period was development and flight of the Flare Genesis Experiment. The FGE is a balloon-borne solar telescope that can provide the sharpest view ever of the evolution of activity on the Sun. The goal of the FGE is to obtain the observations needed for a breakthrough in solar flare research both sooner and at significantly lower cost than either a satellite or adaptive optics can offer.

Construction of the FGE was completed in early 1995, and in August of that year, the telescope and its gondola were integrated with the balloon control mechanisms and shipped to Antarctica.

In January 1996, the Flare Genesis Experiment floated in the stratosphere and pointed continuously at the sun for 19 days. Here is a summary of the achievements on the flight:

- Gondola and mirrors: survived launch, descent and landing without significant damage.
- Thermal performance: all key components remained in their safe operating range (polarization modulators reached 50 C, the limit of the recommended range).
- Telemetry: the high-speed, line-of-sight uplink after launch was maintained for 18 h, to a slant range of 490 km. Downlink was maintained for 20 h to a distance of 560 km.
- Computer systems: operated relatively successfully for the full 19 d. Total data recorded on-board was 23 GB or about 14000 images plus engineering data.
- Pointing: the pointing servo controller maintained pointing in Track State 3 (20 arcsec rms) for at least 95% of the time.
- Main telescope: about one wave out of focus and could not be effectively adjusted because of loss of the very-high-speed link, which was to have sent down images.
- The on-board storage tape drives functioned well. The reason for recording 23 GB of data instead of 100 GB is still under investigation.

A detailed report on the telescope performance is available, and a scientific report on the deconvolution techniques used and the scientific conclusions on the photospheric proper motions and solar oscillations is in preparation.

The FGE can be flown several more times in the next few years and the engineering problems encountered on the first flight can be corrected. This is the inherent advantage in approaching space with a recoverable payload.

The FGE flight was an historic first. We have shown that a meter-class solar telescope can take advantage of the modern long-duration ballooning program in Antarctica to achieve science goals that are central to solar activity research.

We have processed and examined about half of the 14,000 FGE image. Co-Investigator Dr. Steve Keil has begun analysis of the photospheric proper motions. Although magnetograms were FGE's highest priority and none were obtained on the first flight, the data did prove that the flight was still quite successful. It will allow us to follow the temporal development of photospheric convection. We should also be able to pinpoint regions of vortical flows and compare them with magnetograms obtained by other observatories. We are particularly interested in whether there is a pattern of clockwise or counterclockwise flows that might correspond to the global patterns of magnetic helicity (negative helicity predominates in the North and positive helicity in the South).

An important part of the work undertaken with support from the subject grant was development of a better theoretical understanding of the origins of solar eruptions. The results of this work are reflected in the attached publication list. In short, there were two important developments: a model of magnetic clouds was developed which explains in a consistent way how a magnetic filament erupting from the sun evolves into a magnetic cloud, as seen at Earth; we also discovered that solar eruptions begin with a sigmoidal brightening in the corona and that the dimensions of the sigmoidal features are precisely those expected in MHD kink instabilities. This insight into the physics of eruptions will help to guide observations of magnetic fields with the FGE. We are trying to understand which key parameters of solar magnetism are responsible for the build up of the energy that is released in the kink instabilities. Finally, the insight gained into the physics of magnetic clouds should eventually lead to improved predictions of the consequences at Earth of well-recorded eruptions.

Publications (since the last report):

Bieber, J. W. and D. M. Rust, The Escape of Magnetic Flux from the Sun, Astrophys. J. 453, 911, 1995.

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Rust, D. M., G. A. Murphy, K Strohbehn, S. L. Keil and C. U. Keller, The Flare Genesis Experiment, Workshop on Measurements and Analyses of the 3-D Solar Magnetic Field, Huntsville, April 11, 1996.

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Rust, D. M., The Flare Genesis Experiment: An Antarctic Long-Duration Balloon Project, NSF Headquarters, Arlington, VA, September 5, 1996.

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Key Words: Solar Research, Solar Magnetograph